Conceivable new recycling of nuclear waste by nuclear power companies in their plants

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Abstract. We outline the basic principles and the needed experiments for a conceivable new recycling of nuclear waste by the power plants themselves to avoid its transportation and storage to a (yet unknown) dumping area. Details are provided in an adjoining paper and in patents pending.

1   Introduction

The recycling of nuclear waste is certainly one of the largest open problems of contemporary science, industry and society. Current studies (see, e.g., [1a]) are essentially conducted under the assumption of first transporting the waste to a (yet unknown) dumping area, and then recycling it, e.g., via the construction of a huge particle accelerator for the individual smashing of the waste nuclei (see, e.g., [1b]).

Even though technically possible and quantitatively predictable on grounds of current knowledge, this approach is not immune from problematic aspects, such as: the high cost of first transporting and storing the waste and then recycling it (estimated in the range of hundred of *billions* of dollars in the U.S. alone [1a], with similar expenditures predicted for Europe); the danger to the public caused by the fact that the transportation of the highly radioactive waste can only occur via ordinary trucks traveling in ordinary streets (thus being predictably opposed by consumer groups); the long time needed for the above recycling (estimated in the range of hundred of years due to the thousands of tonnages of radioactive waste to be recycled); etc.

In this note we initiate the study of novel means of recycling nuclear waste specifically conceived to be usable by the nuclear power companies in their own plants, e.g., in their water pools, thus avoiding altogether the costly and dangerous transportation of the waste to a dumping area. The new recycling might also stimulate a new industry for the development and production of the needed new equipment for all interested nuclear power plants.

Due to the practical impossibility of building large particle accelerators inside nuclear power plants, the only possible alternative is to identify means capable of disrupting the nuclei of the waste via resonating or other mechanisms, so as to drastically reduce meanlives from current values of the order of thousands of years, down to values of the order of weeks or days.

It should be indicated from the outset that the latter means *are not* predicted by relativistic quantum mechanics (RQM) and its underlying Poincaré symmetry $P(3.1)$ because, in their realization via the familiar Dirac equation, the latter structures predict perennial and immutable meanlives. Thus, quantitative studies of the desired new forms of recycling nuclear waste "in house" require a suitable broadening of RQM and related Poincaré symmetry.

In this note we recall that RQM is *exactly* valid for the atomic structure but *not* for the nuclear structure with predicted small deviations of crucial

relevance for the desired recycling; we point out a broadening of RQM known under the name of *relativistic hadronic mechanics* (RHM) with corresponding broadening of its basic Poincaré symmetry, specifically constructed for the nuclear structure with extended and deformable nucleons; we point out that the alterability of the *intrinsic* magnetic moment of nucleons is a necessary condition for the representation of total nuclear magnetic moments and we present its first exact-numerical representation via RHM under conventional values of spin and angular momentum; we indicate that the alterability of the intrinsic magnetic moments of the neutron implies the alterability of its meanlife via *subnuclear* processes; we present the basic principle of the proposed new recycling of nuclear waste based on subnuclear resonating mechanism which stimulate the beta decay of the neutron; and we finally point out three fundamental experiments which are essential for additional studies in the proposed new recycling.

A detailed presentation is available in the adjoining paper [1c] and in patents pending. The reader should be warned against unreasonable expectations of quick solutions in view of the magnitude and complexity of the problem whose solution will predictably require a comprehensive collegial effort encompassing all current and new scientific and industrial knowledge in nuclear physics.

2 Lack of exact character of relativistic quantum mechanics in nuclear physics

RQM resulted to be exact for the atomic structure because it represented in an *exact way* all its experimental data. By comparison, RQM *cannot* be *exact* for the nuclear structure because it has been unable to provide an *exact* representation of *all* its experimental data, such as total magnetic moments and other data [2]. The understanding is that RQM does indeed provide a good *approximation* of nuclear data. However, as we shall see, even though evidently small, the expected deviations have a fundamental role for the desired new recycling of nuclear waste.

The lack of exact character of RQM in nuclear physics can also be seen in a number of independent ways, a compelling one being that based on symmetries. Computer visualization of the Poincaré symmetry indicates its

capability to represent *Keplerian systems*, i.e., systems with the heaviest constituent in the center, as occurring in the atomic structure. By comparison, *nuclei do not have nuclei* and, therefore, the Poincaré symmetry must be broken to represent structures *without* the Keplerian center. In turn, as we shall see, the latter breaking is fully in line with the deviations from $P(3.1)$ required by the representation of nuclear magnetic moments.

The most compelling arguments are of *dynamical* nature. RQM was constructed for the characterization of action-at-a-distance interactions derivable from a potential, as occurring in the atomic structure. By comparison, nucleons in a nuclear structure are in an average state of mutual penetration of about 10^{-3} parts of their charge distribution [3a]. But hadrons are some of the densest objects measured in laboratory until now. Their mutual penetration therefore implies a (generally small) component of the nuclear force which is: 1) of *contact* type i.e., with zero-range, thus requiring new interactions *without* particle exchanges; 2) *nonlinear* in the wave functions and, possibly, their derivatives, thus requiring a theory with an exact superposition principle under said nonlinearity; 3) *nonlocal*, e.g., of integral-type over the volume of overlapping, thus requiring a new topology; 4) *nonpotential*, in the sense of violating the conditions to be derivable from a potential or a Hamiltonian [3b], thus requiring new dynamical equations; and 5) of consequential *nonunitarity* type as a necessary condition to exit from the equivalence class of RQM, thus requiring new mathematical methods.

3   Relativistic hadronic mechanics

The insufficiencies of RQM for the nuclear structure (as well as for the structure of hadrons and stars here ignored) have been recognized by various physicists, resulting in a number of research lines, such as the well known *q-deformations, quantum groups,* and others. Unfortunately, even though *mathematically* impeccable, these deformations are afflicted by a number of problematic aspects of *physical* character [3c], besides implying an evident departure from the axioms of the special relativity (SR).

In this note we use a covering of RQM known as *relativistic hadronic mechanics* (RHM), originally submitted and studied by Santilli [4] (for independent studies see monographs [5] and papers quoted therein), which apparently resolves the above problematic aspects, and permits quantitative

and invariant studies of nuclear structures with extended, nonspherical and deformable nucleons under nonlinear, nonlocal and nonunitary nuclear forces [4h].

RHM is constructed via axiom-preserving maps of RQM called *isotopies* [4a] here referred to *maps of any given linear, local-differential and unitary theory into its most general possible nonlinear, nonlocal-integral and nonunitary extensions which are nevertheless capable of reconstructing linearity, locality and unitarity on certain generalized spaces called isospaces, over certain generalized fields called isofields.* The alterations characterized by RHM are called *mutations* [6] in order to distinguish them from the "deformations" of the current literature.

The representation of physical systems via RHM requires [1c,4h] the knowledge of *two* quantities: the Hamiltonian H for the representation of all potential interactions; and the isotopic generalization of the conventional unit $I = \mathrm{diag}(1, 1, 1, 1)$ of RQM, called *isounit*, $\hat{I} = \mathrm{Diag}(n_1{}^2, n_2{}^2, n_3{}^2, n_4{}^2) \times \hat{\Gamma}(x, \dot{x}, \psi, \partial\psi, \ldots) = \hat{I}^\dagger > 0$, where $n_1{}^2, n_2{}^2, n_3{}^2$ represent *extended, nonspherical and deformable shapes of the nucleons* under the volume preserving condition $n_1{}^2 \times n_2{}^2 \times n_3{}^2 = 1$, $n_4{}^2$ represents the *density of the medium in which motion occurs* (e.g., the square of the local index of refraction), and $\hat{\Gamma}$ represent all nonlinear, nonlocal and nonpotential interactions.

The *isotopic lifting* of the basic (multiplicative) unit $I \to \hat{I}$ requires, for consistency, the corresponding lifting of the conventional associative product $A \times B$ of RQM into the *isoproduct* $A \hat{\times} B = A \times \hat{T} \times B$, $\hat{I} = \hat{T}^{-1}$, under which $\hat{I}$ is the correct left and right unit of the new theory, $\hat{I} \hat{\times} A \equiv A \hat{\times} \hat{I} \equiv A$ [4a]. The *totality* of the products of RHM must therefore be isotopic for consistency.

A realization of RHM specifically conceived for the nuclear structure is presented in the adjoining paper [1c]. In essence, RQM can be reconstructed with respect to the new isounit $\hat{I}$ with isoproduct $A \hat{\times} B$ via the use of *nonunitary transforms*. In fact, for $U \times U^\dagger \neq I$, the isounit is precisely given by the transform $I \to \hat{I} = U \times I \times U^\dagger = \hat{I}^\dagger$, the isoproduct is precisely given by the transform $A \times B \to U \times A \times B \times U^\dagger = \hat{A} \times \hat{T} \times \hat{B} = \hat{A} \hat{\times} \hat{B}$, $\hat{A} = U \times A \times U^\dagger$, $\hat{B} = U \times B \times U^\dagger$, $\hat{T} = (U \times U^\dagger)^{-1} = \hat{I}^{-1}$, the fundamental relativistic commutation rules are subjected to the map $[p_\mu, x^\nu] = \delta_\mu{}^\nu \times I \to U \times [p_\mu, x^\nu] \times U^\dagger = [\hat{p}_\mu \hat{,} \hat{x}^\nu] = \hat{p}_\mu \hat{\times} \hat{x}^\nu - \hat{x}^\nu \hat{\times} \hat{p}_\mu = -i\delta_\mu{}^\nu \times \hat{I}$, etc.

The reader should be aware that the above procedure implies: new field

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$\hat{F}$ ($=\hat{R}$ or $\hat{C}$ of real or complex) *isonumbers* $\hat{n} = n \times \hat{I}$ [4c]; new *isodifferential calculus* with $\hat{d}x^\mu = \hat{I}^\mu_\nu \times dx^\nu$, $\hat{\partial}/\hat{\partial}x = \hat{T}^\nu_\mu \partial/\partial x^\nu$ [4g]; new *isolinear momentum operator* $\hat{p}_\mu \hat{\times} |\hat{\psi}> = -i\hat{\partial}_\mu |\hat{\psi}> = -i\hat{T}^\nu_\mu \partial_\nu |\hat{\psi}>$; new *iso-Hilbert space* $\hat{\mathcal{H}}$ with inner product $<\hat{\phi}| \times \hat{T} \times |\hat{\psi}> \times \hat{I} \in \hat{C}$ and normalization $<\hat{\psi}| \times \hat{T} \times |\hat{\psi}> = I$; new *isoeigenvalue equations* $\hat{H} \hat{\times} |\hat{\psi}> = \hat{E} \hat{\times} |\hat{\psi}> \equiv E \times |\hat{\psi}>$, $E \in F$, $\hat{E} = E \times \hat{I} \in \hat{F}$; new *Lie-Santilli isotheory* [5] based on the isoproduct $[\hat{A}\hat{,}\hat{B}] = \hat{A} \hat{\times} \hat{B} - \hat{B} \hat{\times} \hat{A}$ [3b,4a]; new *iso-Minkowski space* [4e] $\hat{M}$ over $\hat{R}$ with isounit $\hat{I} = \hat{T}^{-1}$, isometric $\hat{N}_{\mu\nu} = \hat{\eta}_{\mu\nu} \times \hat{I} = \hat{T}^\alpha_\mu(x, \dot{x}, \hat{\psi}, \partial\hat{\psi}, \ldots) \times \eta_{\alpha\nu} \times \hat{I}$, $\eta = \text{diag}\,(1,1,1,-1)$, and isoseparation $(x-y)^{\hat{2}} = [(x-y)^\mu \hat{\eta}_{\mu\nu}(x-y)^\nu] \times \hat{I} \in \hat{R}$; a new image $\hat{P}(3.1)$ of the Poincaré symmetry first introduced by Santilli [4d-4f] under the name of *iso-Poincaré symmetry*; new *isofunctional analysis* [5c,5e]; etc. For the reconstruction in isospaces over isofields of all axiomatic properties of RQM, such as hermiticity, real-valuedness of Hermitean operators, linearity, locality, unitarity, etc., we are forced to refer the reader to ref. [1c,4h].

We merely recall here that $\hat{P}(3.1)$ is the image of $P(3.1)$ for the new unit $\hat{I}$. As such, $\hat{P}(3.1)$ is the universal invariance of the isoseparation $(x-y)^{\hat{2}}$, that is, of a geometry whose unit $\hat{I}$ directly represents extended, nonspherical and deformable particles under unrestricted, generally nonunitary external forces. As such, computer visualization of $\hat{P}(3.1)$ show the desired removal of the Keplerian center, as assured by the presence of contact/zero-range interactions.

We should also recall that RHM is characterized by new degrees of freedom of RQM axioms which are given for constant $\hat{I} = n^2$ by the Hilbert space law $<\phi| \times |\psi> \times I \equiv <\phi| \times n^{-2} \times |\psi> \times n^2 = <\phi| \times \hat{I} \times \psi> \times \hat{I}$ with Minkowskian counterpart $x^2 = (x^\mu \times \eta_{\mu\nu} \times x^\nu) \times I \equiv (x^\mu \times (n^{-2} \times \eta_{\mu\nu}) \times x^\nu) \times n^2 = (x^\mu \times \hat{\eta}_{\mu\nu} \times x^\nu) \times \hat{I}$. Note that these new invariances have remained undetected during this century because they required the prior discivery of *new numbers with arbitrary units* $\hat{I}$ [4c].

Also, RHM provides an explicit and concrete "operator" realization of the "hidden variables" $\lambda = \hat{T}(x, \hat{\psi}, \ldots)$ via the isoeigenvalue equation $\hat{H} \hat{\times} |\hat{\psi}> = \hat{H} \times \lambda \times |\hat{\psi}> = \hat{E} \hat{\times} |\hat{\psi}> = (E \times \lambda^{-1}) \times \lambda \times |\hat{\psi}> = E \times |\hat{\psi}>$. As such, RHM is a form of "completion" of RQM much along the celebrated argument by Einstein, Podolsky and Rosen for which von Neumann's theorem, Bell's inequalities and all that do not apply owing to the underlying *nonunitary* structure (see [1c,4h] for details).

An important property is that (for positive-definite isounits) all isotopic

structures are locally isomorphic to the original ones, $\hat{F} \approx F$, $\hat{\mathcal{H}} \approx \mathcal{H}$, $\hat{M} \approx M$, $\hat{P}(3.1) \approx P(3.1)$, etc., and they coincide at the abstract, realization-free level by conception and construction. Possible criticisms on the axiomatic structure of RHM (generally due to lack of sufficient technical knowledge of this new field) are therefore criticisms on the axiomatic structure of RQM. In fact, RHM *is not* a new mechanics, but merely a *new realization* of the abstract axioms of RQM, although the two realizations are *physically inequivalent* because connected by nonunitary transforms.

The reader should be aware that RHM admits a hierarchy of realizations to represent a hiererchy of physical conditions of increasing complexity, ranging from the minimal conditions of mutual overlapping of hadrons in the nuclear structure, to their maximal conditions of mutual penetration in the interior of collapsing stars. The realization needed for nuclear physics is constructed for the first time in the adjoint paper [1c], and it is conceived to *preserve conventional quantum laws*. In fact, we have the conventional uncertainties $\Delta \hat{r} \Delta \hat{p} \geq \frac{1}{2} < [\hat{p}, \hat{x}] = \frac{1}{2} < \hat{\psi}| \times \hat{T} \times \hat{I} \times \hat{T}|\hat{\psi} > / < \hat{\psi}| \times \hat{T} \times |\hat{\psi}> = \frac{1}{2}(\hbar = 1)$; the conventional spin $\frac{1}{2}$ and related Pauli's exclusion principle; and other conventional laws. Note that this implies the preservation by RHM of causality under nonlocal interactions (because they are embedded in the unit), the validity of the superposition principle for a highly nonlinear theory (because of the reconstruction of linearity in isospace), the invariance under nonunitary time evolutions (because they are reduced to the isounitary law $W = \hat{W} \times \hat{T}^{1/2}$, $W \times W^{\dagger} \equiv \hat{W} \hat{\times} \hat{W}^{\dagger} = \hat{W}^{\dagger} \hat{\times} \hat{W} = \hat{I} \neq I$), and other features [1c,4h] which are impossible for the conventional formalism of RQM.

Above all, *RHM is based on the requirement of preserving the axioms of the SR and merely realize them in isospace $\hat{M}$ under the isosymmetry $\hat{P}$ (3.1)* [4]. This permits to extend the applicability of the SR from the current restriction to elm waves or perfectly spherical and rigid bodies moving in vacuum with maximal speed c_0, to elm waves or nonspherical-deformable bodies moving within physical media with maximal speed $c = c_0/n_4$. In particular, the maximal causal speed on $\hat{M}$ remains c_0 because in the fourth component of the isotopic line element we have the lifting $c_0^2 \rightarrow c^2 = c_0^2/n_4^2$, with the *inverse* lifting of the related unit $I_{44} = I \rightarrow \hat{I}_{44} = n_4^2$, under which the conventional value c_0 is invariant, thus rendering the SR universal [4h].

Nowadays RHM possesses several preliminary, yet numerical and significant verifications in nuclear physics, particle physics, astrophysics, superconductivity, biology and other fields which we cannot possibly review here for

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lack of space [4,5].

4   Exact representation of total nuclear magnetic moments

As indicated earlier, total nuclear magnetic moments still lack an exact representation via RQM after three-quarter of a century of studies. For instance, for the deuteron we have the value $\hat{\mu}_D^{\text{exp}} = 0.857$, while: quantum mechanics yields the value $\mu_{\text{QM}}^{\text{theor}} = 0.880$ which is 2.6 % off *in excess* [2a]; all possible corrections via RQM still remain with about 1 % off [2b]; and the problem does not appear to be solvable via quark models because the quark orbits are too small to yield the needed deviation.

The most plausible explanation of the above occurrence was formulated by the Founding Fathers of nuclear physics in the late 1940's [2a]. Recall that nucleons are not point like, but have extended charge distributions with the radius of about 1 fm. Since perfectly rigid bodies do not exist in nature, the above "historical hypothesis" (as hereon referred to) assumes that such distributions can be deformed under sufficient external forces. But the deformation of a charged and spinning sphere implies a necessary alteration of its intrinsic magnetic moment. In turn, this permits the exact representation of total nuclear magnetic moments as shown below.

Our fundamental assumption is that the exact representation of total nuclear magnetic moments requires the lifting RQM $\rightarrow$ RHM, with basic lifting $P(3.1) \rightarrow \hat{P}(3.1)$. As recalled earlier, the intrinsic characteristics of nucleons are perennial and immutable under $P(3.1)$, while $\hat{P}(3.1)$ has been constructed precisely to represent their alterability under sufficient conditions.

One of the first experimental verifications of RHM is then the exact-numerical representation of total nuclear magnetic moments. It was presented for the first time in ref. [6] under a joint mutation of angular momentum and spin. In this note we give a new representation under mutated magnetic moments but conventional values of angular momentum and spin.

The fundamental equation of RHM needed for quantitative treatment of the historical hypothesis is the isotopic image of Dirac's equation, called *iso-Dirac equation* [4h]. It is characterized by a nonunitary image of the conventional equation and can be written for total 6-dimensional isounits

$$\hat{I}_{\text{tot}} = \hat{I}^{\text{orb}} \times \hat{I}^{\text{spin}}, \ \hat{I}^{\text{orb}} = \text{Diag}\,({n_1}^2, {n_2}^2, {n_3}^2, {n_4}^2) \times \hat{\Gamma} = \text{Diag}\,(\hat{I}_{11}, \hat{I}_{22}, \hat{I}_{33}, \hat{I}_{44}),$$
$$\hat{I}^{\text{spin}} = U^{\text{spin}} \times U^{\dagger \text{spin}} \neq \hat{I} \ (\text{see [1c] for details})$$

$$[\hat{N}^{\mu\nu} \hat{\times}^{\text{orb}} \hat{\gamma}_\mu \hat{\times}^{\text{spin}} (\hat{p}_\nu - \hat{i} \hat{\times} \hat{e} \hat{\times} \hat{A}_\nu) - i \times \hat{m}^2] \hat{\times}^{\text{orb}} \hat{\psi} = 0 \,, \qquad (1a)$$

$$\{\hat{\gamma}_\mu, \hat{\gamma}_\alpha\} = \hat{\gamma}_\mu \times \hat{T}^{\text{spin}} \times \hat{\gamma}_\alpha + \hat{\gamma}_\alpha \times \hat{T}^{\text{spin}} \times \hat{\gamma}_\mu = 2\hat{\eta}_{\mu\alpha} \times \hat{I}^{\text{spin}} \,, \qquad (1b)$$

$$\hat{\gamma}_\mu = (\hat{T}^{\text{orb}}_{\mu\mu})^{1/2} \times U^{\text{spin}} \times \gamma_\mu \times U^{\dagger \text{spin}} \times \hat{I}^{\text{spin}} \,, \qquad (1c)$$

where $\hat{i} \hat{\times} \hat{e} \hat{\times} \hat{A}_\mu = (i \times e \times A_\mu) \times \hat{I}$ and the elm potential A_μ is conventional, being external and long range.

As one can see, the above equation represents particles, which: a) are extended and deformable with all infinitely possible ellipsoidical shapes with semiaxes ${n_1}^2$, ${n_2}^2$, ${n_3}^2$ (under the volume preserving condition ${n_1}^2 \times {n_2}^2 \times {n_3}^2 = 1$); b) propagating within a physical medium with index of refraction n_4 (of value generally different than 1); and c) under conventional electromagnetic interactions plus unrestricted external forces (represented by $\hat{\Gamma}$). When a system is considered from the exterior, all nonlocal-nonpotential internal effects must evidently be averaged into constants (due to their short range character), as it is the case for total nuclear magnetic moments. This yields a mere isorenormalization of the n_μ's hereon tacitly implied.

It is easy to see that iso-Dirac equation (1) preserves the conventional eigenvalues of angular momentum and spin due to its very construction via nonunitary transform of conventional equations (see [1c] for details), while providing the desired *mutation of the magnetic moment of nucleons* [4b,6,1b]

$$\hat{\mu}_N = \mu_N \times n_4/n_3 \,, \quad N = n \text{ or } p \,. \qquad (2)$$

The application to the *exact* representation of total nuclear magnetic moments is straightforward. Assume to a good approximation that protons and neutrons have the same shape $(n_{kn} = n_{kp})$ and that they move in the same medium $(n_{4n} = n_{4p})$. Then, a simple isotopy of the QM model [2a] yields the *RHM model for the total nuclear magnetic moments*

$$\hat{\mu}^{\text{tot}} = \sum_k (\hat{g}_k^L \times \hat{M}_{k3} + \hat{g}_k^S \times \hat{S}_{k3}) \,, \qquad (3a)$$

$$\hat{g}_n = g_n n_4/n_3 \approx g_n/n_3 \,, \quad \hat{g}_p = g_p n_4/n_3 \approx g_p/n_3 \,, \qquad (3b)$$

where $e\hbar/2m_pc_0 = 1$, $g_n^S = -3.816$, $g_p^S = 5.585$, $g_n^L = 0$, $g_p^L = 1$. As an illustration, the above model yields the following *exact representation of the deuteron magnetic moment*

$$\hat{\mu}_{\text{theor}}^{\text{tot}} = g_p n_{4p}/n_{3p} + g_n n_{4n}/n_{3n} \approx (g_p + g_n)n_4/n_3 \equiv \mu_D^{\text{exp}} = 0.857 , \quad (4a)$$

$$n_4{}^2 = 1.000 , \quad n_3{}^2 = 1.054 , \quad n_1{}^2 = n_2{}^2 = (1/n_3{}^2)^{1/2} = 0.974 . \quad (4b)$$

As one can see, μ_D^{exp} is exactly represented by merely assuming that the charge distribution of the nucleons in the deuteron experiences a deformation of shape of about $1/2$ %. Note that the mutation is of *prolate* character which implies a *decrease* of the (absolute value of the) intrinsic magnetic moment of nucleons exactly as needed. Note also that the representation is of *geometric* character; it is independent from any assumed nucleon constituent; and it identifies the polarization of the constituent orbits which is needed for their compliance with physical reality. Corrections due to the value $n_4 \neq 1$ for the deuteron are of 2-nd or higher order (due to the relatively large nucleon distace in the deuteron).

The application of the model (3) to the exact representation of the total magnetic moment of tritium, helium and other nuclei is straightforward and studied in a future work.

Note that, the mutation of the charge distribution of the nucleons *is not* a universal constant, because it depends on the local conditions, thus being generally different for different nuclei. This illustrates the need of having infinitely possible *different* isounits $\hat{I}$.

5 The basic principle for possible new recycling of nuclear waste

RHM in its nuclear realization [1c] and the fundamental iso-Poincaré symmetry [4c-4f] predict the possible mutation not only of the intrinsic magnetic moment of the neutron, but also of its meanlife, to such an extent that the former implies the latter and *vice versa* (as one can see via the use of the isoboosts). In turn, the control of the meanlife of the neutron *de facto* implies new means for recycling the nuclear waste.

In this respect, the first physical reality which should be noted and admitted is that total nuclear magnetic moments constitute *experimental evidence* on the alterability of the intrinsic magnetic moments of nucleons.

The second physical reality which should be noted and admitted is that, by no means, the neutron has a constant and universal meanlife, because it possesses a meanlife of the order of seconds when belonging to certain nuclei with rapid beta decays, a meanlife of the order of 15 minutes when in vacuum, a meanlife of the order of days, weeks and years when belonging to other nuclei, all the way to an infinite meanlife for stable nuclei.

Once the above occurrences are admitted, *basic principle for possible new recycling of nuclear waste is the "stimulated neutron decay"* (SND) *consisting of resonating or other subnuclear mechanisms suitable to stimulate its beta decay.* Among the various possibilities under study, we quote here the possible *gamma stimulated neutron decay* (GSND) according to the reaction [7b]

$$\gamma + n \rightarrow p^+ + e^- + \bar{\nu} \,, \tag{5}$$

which is predicted by RQM to have a very small (and therefore practically insignificant) cross section as a function of the energy, but which is instead predicted by RHM to have a resonating peak in said cross section at the value of 1.294 MeV (corresponding to 3.129×10^{20} Hz). As such, the above mechanism is of *subnuclear* character, in the sense of occurring in the *structure of the neutron*, rather than in the nuclear structure, the latter merely implying possible refinements of the resonating frequency due to the (relatively smaller) nuclear binding energy [7b].

When stable elements are considered, the above GSND is admitted only in certain instances, evidently when the transition is compatible with all conventional laws. This is the case for the isotope Mo(100,42) which, under the GSND, would transform via beta emission into the Te(100,43) which, in turn, is naturally unstable and beta decays into Ru(100,44). For a number of additional admissible elements see [7b].

The point important for this note is that the GSND is predicted to be admissible for large and unstable nuclei as occurring in the nuclear waste. The possible new form of recycling submitted for study in this note is given by *bombarding the radioactive waste with a beam of photons of the needed excitation frequency and of the maximal possible intensity.* Such a beam

would cause an instantaneous excess of peripheral protons in the waste nuclei with their consequential decay due to instantaneous excess of Coulomb repulsive forces.

It should be stressed that this note can only address the basic *principle* of the GSND. Once experimentally established (see next section), the recycling requires evident additional technological studies on the *equipment* suitable to produce the photon beam in the desired frequency and intensity, eg., via synchrotron radiation or other mechanisms [7e].

The important point is that equipment of the above nature is expected to be definitely smaller in size, weight and cost than large particle accelerators. As such, the recycling is expected to verify the basic requirement of usability by the nuclear power companies in their own plants.

A novelty of this note is that the study of recycling mechanisms is specifically restricted to the *subnuclear* level. A virtually endless number of possibilities exist for the reduction of the meanlife of the waste via mechanisms of *nuclear* type. Among them we note mechanisms based on RQM, such as those by Shaffer et al. [8a], Marriot et al. [8b], Barker [8c] and others, as well as new *nuclear* mechanisms predicted by RHM and currently under additional patenting. The understanding is that, to maximize the efficiency, the final equipment is expected to be a combination of various means of both subnuclear and nuclear character.

As a final comment, the reader should be aware that any new recycling of nuclear waste is unavoidably linked to possible new sources of energy. In fact, the GSND $\gamma_{\mathrm{res}} + \mathrm{Mo}(100, 42) \stackrel{\mathrm{stim}}{\rightarrow} \mathrm{Tc}(100, 43) + \beta \stackrel{\mathrm{spont}}{\rightarrow} \mathrm{Ru}(100, 44) + \beta$ is *de facto* a potential new source of *subnuclear* energy (releasing the rather large amount of about 5 MeV plus the energy of the γ_{res} per nucleus) called *hadronic energy* [7b-7g]. It should be noted that, it confirmed, the new energy would not release harmful radiations, would not imply radioactive waste, would not require heavy shield or critical mass, and would be realizable in large or minuterized forms, thus having ample prerequisites for additional studies.

6   Needed basic experiments

The continuation of quantitative scientific studies on the proposed new recycling of the nuclear waste (as well as on possible subnuclear forms of clean

energy) beyond the level of personal views one way or another, requires the following three basic experiments, all of moderate cost and fully realizable with current technology.

1. Finalize the interferometric 4π spinorial symmetry measures [9]. Preliminary direct experimental measures on the alterability of the *intrinsic* magnetic moments of nucleons were conducted from 1975 to 1979 by H. Rauch and his associates [9a-9e] via interferometic measures of the *4π spinorial symmetry* of the neutron. The best available measures [9e] dating back to 1979 indicate about 1% deviations from 720°. But such deviation is *smaller* than the error, and the measures are therefore undefined. Similar unsettled measures were conducted by Werner and his associates [9f] in the mid 1970's.

The above measures are manifestly fundamental for possible new forms of recycling as well as for possible new forms of subnuclear energy. In fact, they would provide experimental evidence on possible deviations from the Poincaré symmetry in favor of our covering iso-Poincaré form [4]. This is due to the fact that, if confirmed, the measures would establish a deviation from the fundamental *spinorial* transformation law of favor of the mutated form easily derivable from Eqs. (1) (first identified in [6], see [1c] for a recent derivation)

$$\hat{\psi}' = \hat{R}(\theta_3)\hat{\times}\hat{\psi} = e^{i\gamma_1\gamma_2\hat{\theta}_3/2} \times \hat{\psi} \,, \quad \hat{\theta} = \theta/n_1 \times n_2 \,, \tag{6}$$

As an illustration, assume a 1% deviation from 720°. The isotopies reconstruct the exact SU(2)-spin in isospace, thus requiring $\hat{\theta} = \theta/n_1 \times n_2 = 720°$ [4h]. This yields

$$n_1{}^2 = n_2{}^2 = 713°/720° = 0.990 \,, \quad n_3{}^2 = 1.020 \,, \tag{7a}$$

$$\hat{\mu}/\mu = n_4/n_3 \approx 713°/720° \,, \quad n_4 = n_3 \times 713°/714° = 1.000 \,, \tag{7b}$$

namely, our iso-Dirac equation provides an *exact-numerical* representation of the 4π interferometric measures, by *deriving* the value $n_4 = 1$ occurring in vacuum, as it is the case for the neutrons of tests [9] (but only approximately so for the deuteron). For more details see [1c].

Once, in addition to the evidence from total nuclear magnetic moments and various other applications [4,5], the validity of the iso-Poincaré symme-

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try is established via direct experiments for the mutation of the intrinsic magnetic moment of the neutron, that of its meanlife is expected to be consequential.

2. Repeat don Borghi's experiment [7f] on the apparent synthesis of the neutron from protons and electrons *only*. Despite momentous advances, we still miss fundamental experimental knowledge on the structure of the neutron, e.g., on how the neutron is synthesized from protons and electrons *only* in young stars solely composed of hydrogen (where quark models cannot be used owing to the lack of the remaining members of the baryonic octet, and weak interactions do not provide sufficient information on the *structure* problem).

The synthesis occurs according to the reaction $p^+ + e^- \rightarrow n + \nu$ which: is the "inverse" of the stimulated decay (5); is predicted by RQM to have a very small cross section as a function of the energy; while the same cross section is predicted by RHM to have a peak at the threshold energy of 0.80 MeV in singlet *p-e* coupling [4f].

The possible synthesis of the neutron has a fundamental relevance for waste recycling, besides other industrial applications. If the electron "disappears" at the creation of the neutron as in current theoretical views, the GSND becomes of difficult if not impossible realization.

However, the electron is a permanent and stable particle. As such, doubts as to whether it can "disappear" date back to Rutherford's very conception of the neutron as a "compressed hydrogen atom" [7a]. As well known, RQM does not permit such a representation of the neutron structure on numerous counts. Nevertheless, the covering RHM has indeed achieved an exact-numerical representation of all characteristics of the neutron according to Rutherford's original conception [4f]. The novelty is that, when immersed within the hyperdense proton, the electron experiences a mutation $e^- \rightarrow \hat{e}^-$ of its *intrinsic* characteristics (becoming a quark ?) including its rest energy (because $n_4 \neq 1$ inside the proton, thus $E_{\hat{e}} = mc^2 + m_e c_0{}^2/n_4{}^2$). The excitation energy of 1.294 MeV is predicted by our covering iso-Poincaré symmetry under the condition of recovering all characteristics of the neutron for the model $n = (p^+{}_\uparrow, \hat{e}^-_\downarrow)_{\mathrm{RHM}}$, including its primary decay for which $\hat{e}^- \rightarrow e^- + \bar{\nu}$ [4f].

A preliminary experimental verification of the synthesize the neutron in laboratory was done by don Borghi's and his associates [7d]. Since experi-

ments can be confirmed or dismissed *solely* via other experiments and certainly not via theoretical beliefs one way or the other, don Borghi's experiment must be run again. The test can be repeated either as originally done [7f], or in a number of alternative ways, e.g., by hitting with a cathodic ray of 0.80 MeV a mass of beryllium saturated with hydrogen, put at low temperature and subjected to an intense electric field to maximize the *p-e* singlet coupling. The detection of neutrons emanating from such a set-up would establish their synthesis.

3. Complete Tsagas' experiment [7g] on the stimulated neutron decay. The last and most fundamental information needed for additional quantitative studies is the verification or disproof of the GSND at the resonating gamma frequency of 1.294 MeV.

The latter experiment has been initiated by N. Tsagas and his associates [7g]. It consists of a disk of the radioisotope Eu^{152} (emitting gammas of 1.3 MeV) placed parallel and close to a disk of an element admitting of the GSND, such as the Mo(100,42) (or a sample of nuclear waste). The detection of electrons with at least 2 MeV emanating from the system would establish the *principle* of the GSND (because such electrons can only be of subnuclear origin, Compton electrons being of at most 1 MeV). The detection via mass spectrography of traces of the extremely rare Ru(100,44) after sufficient running time would confirm said principle. The practical realization of the proposed form of waste recycling would then be shifted to the industrial development and production of a photon beam of the needed frequency and intensity.

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